Culminating Task – SPH3U Grade 11 Physics – Waves and Sound

**Student Handout**

**Make and Play Your Own Pan Pipes**

Your task for this activity is to **construct** a working set of pan pipes and then **play a simple song in groups of 3** to demonstrate that you have successfully converted your knowledge of waves and sound into a real working instrument. In addition you will have to explain and show with a diagram the physics and calculations behind your instrument.

The point of this exercise is to demonstrate that you can use the formulas associated with sound and waves to solve real world problems. The dimensions for your pan pipe could be made through trial and error, or by looking at someone else’s work online, however I want you to show me your understanding of waves and sound by doing the calculations yourself.

**Timelines/Deliverables**

**2 Weeks (date \_\_\_\_\_\_\_\_\_\_):** Draft of your calculations and diagram of what your panpipe will look like. Draw your diagram to scale. For example if your longest pipe is 30cm and it won’t fit on the page then use a 2:1 scale where every dimension is ½ the true length (your longest pipe in this case would be 15cm in the diagram).

**4 Weeks (date \_\_\_\_\_\_\_\_\_\_):** Panpipe presentations due along with your calculations and diagrams used to construct it.

Pan Pipe Specifications:

* Will contain 7 pipes, one for each note on the “C” scale namely: C, D, E, F, G, A, B.
* You have 3 choices in setting the pitch of your Pan Pipe. Each member of the group will choose **one (1) pitch** so that your group of 3 instruments will cover 3 octaves of the piano. Your “C” pipe can be tuned to one of the following:
  + Your “C” pipe will be “middle C” on the piano, or
  + Your “C” pipe will be the “C” one octave above middle “C’ on the piano, or
  + Your “C” pipe will be the “C” 2 octaves above middle “C” on the piano.
* Your other 6 pipes will be tuned to each of the corresponding notes in your “C” scale (D, E, F, G, A, B)
* Your Pan Pipe will use closed pipes (think about why you are not using open tubes)

**Pipe Length Determination:**

You are expected to determine the length of each pipe from first principal (original work) using the proper wave formula (show your work!). Some important information that you should know:

* The speed of sound in air
* The frequency of the sound produced by each of the notes on your Pan Pipe. Be sure to note where on the piano you are tuning your Pan Pipe to.

**Hint:** Google “frequency, scale and C” and note that some sites refer to Middle “A” instead of middle “C”.

**Important Note:** Your calculations must be **hand written** on the sheet you hand in.

**Frequently Asked Questions (FAQ’S)**

**Q.** What is a Pan Pipe?

**A.** “The **pan flute** or **pan pipe** (also known as **panflute** or **panpipes**) is an ancient musical instrument based on the principle of the closed tube, consisting usually of five or more pipes of gradually increasing length (and, at times, girth). The pan flute has long been popular as a folk instrument, and is considered the first mouth organ, ancestor of both the pipe organ and the harmonica. The pan flute is named for its association with the rustic Greek god Pan. The pipes of the pan flute are typically made from bamboo or giant cane; other materials used include wood, plastic, and metal.”

(http://en.wikipedia.org/wiki/Pan\_flute)

**Q**. What will my panpipes be made out of?

**A.** You will be manufacturing your pan pipe out of PVS piping that will be supplied by the school.

**Q**. How do I hold everything together?

**A**. Duct Tape! (or other methods you can think of)

**Q**. What does a Pan pipe look like?

**A**. (<http://www.eriktheflutemaker.com/Panpipes.htm>)

Open End of Pipe

[](http://www.google.ca/imgres?q=pan+pipes&um=1&hl=en&sa=N&biw=1024&bih=560&tbm=isch&tbnid=QdyR-S7DeOWHAM:&imgrefurl=http://www.eriktheflutemaker.com/Panpipes.htm&docid=5LA9mpilzZmNFM&imgurl=http://www.eriktheflutemaker.com/images/PanPipeLeoHojaDoblada.jpg&w=358&h=238&ei=rEmnTtHSOMfzsgbv-MjEDQ&zoom=1) Closed End of Pipe

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**Teacher Notes**

**Determining the length of each pipe:**

The air inside a closed or open pipe will vibrate in its natural harmonics if it is vibrated by an external source. If the frequency of the source and the length of pipe are matched properly, then standing waves are established where the incoming wave positively interferes with the outgoing wave causing certain areas to act as if they are not moving (nodes) and other areas to move at an amplitude equal to the sum of both waves (antinodes) as shown in Fig. 1.

Node Antinode

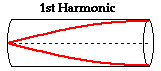


Fig. 1: First Harmonic in a closed tube.

The distance between adjacent antinodes on a standing wave pattern is equivalent to one-half of a wavelength. Since nodes always lie midway in between the antinodes, the distance between an antinode and a node must be equivalent to one-fourth of a wavelength. Thus, the length of the air column is equal to one-fourth of the wavelength for the first harmonic (see Fig. 2).

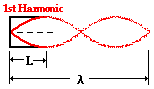


Fig. 2: Length of closed pipe vs. total wavelength

To calculate the length of pipe needed to produce “middle C” the following equation must be used:

Speed of sound in air = frequency • wavelength

Wavelength = speed / frequency

Length of pipe = ¼ \* wavelength

= ¼ \* speed/frequency

Known quantities: Speed of sound in air = 343.2 metres per second

Frequency of Middle C = 261.63

Therefore the length of pipe = ¼ \* 342.2/261.63 = 0.327 m = **32.7 cm for middle C**

|  |  |  |  |
| --- | --- | --- | --- |
| Notes | Middle C scale frequencies | Octave above middle C scale frequencies | 2 Octaves above middle C scale frequencies |
| C | 261.63 | 523.26 | 1046.52 |
| D | 293.63 | 587.26 | 1174.52 |
| E | 329.63 | 659.26 | 1318.52 |
| F | 349.23 | 698.46 | 1396.92 |
| G | 392.00 | 784.00 | 1568.00 |
| A | 440.00 | 880.00 | 1760.00 |
| B | 493.88 | 987.76 | 1975.52 |

Fig 3: List of all the frequencies the students will need to find.

Notes:

* Songs chosen for this task should be short and easy to play (this is not a music class). Nursery rhymes work well.
* There is no “best” way to hold the pipes together. As long as they are reasonably well held together and can be played without trouble then the application aspect of the task should be considered complete.
* A panpipe is played by gently blowing across the top of each open pipe so that a smooth note is heard. Each pipe represents 1 note so there is no use of the fingers in the playing of the instrument.
* A standard guitar tuner is sufficient to check the frequency of the pipes.
* This task covers the following achievement chart categories:
  + Knowledge and Understanding
  + Communication
  + Application.

**Scoring Rubric for Waves and Sound Culminating Activity - Panpipes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Category | Level 1 | Level 2 | Level 3 | Level 4 |
| Calculations of pipe lengths | The background research and calculations were done with limited effectiveness. | The background research and calculations were done with some effectiveness. | The background research and calculations were done with considerable effectiveness. | The background research and calculations were done with a high degree of effectiveness. |
| Calculations are original (handwritten) | Calculations are typed in. | Calculations are handwritten but difficult to follow | Calculations are handwritten and east to follow | Calculations are hand written and of exceptional quality |
| Building of the Panpipe | Construction of the panpipes is based on the calculations with limited effectiveness. | Construction of the panpipes is based on the calculations with some effectiveness. | Construction of the panpipes is based on the calculations with considerable effectiveness. | Construction of the panpipes is based on the calculations with a high degree of effectiveness. |
| The quality of the Panpipe | Construction of the Panpipe allows it to be played with limited effectiveness. | Construction of the Panpipe allows it to be played with some effectiveness. | Construction of the Panpipe allows it to be played with considerable effectiveness. | Construction of the Panpipe allows it to be played with a high degree of effectiveness. |
| The panpipe is in tune (compared with the tuner) | The panpipe is strongly out of tune. | The panpipe is somewhat in tune. | The panpipe is mostly in tune. | The panpipe is in tune. |
| Playing the final piece of music (group mark) | The piece of music is played with limited effectiveness. | The piece of music is played with some effectiveness. | The piece of music is played with considerable effectiveness. | The piece of music is played with a high degree of effectiveness. |